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Just in Time, Quality Management, Supply Chain Management, and Business Performance: A Structural Analysis

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JUST IN TIME, QUALITY MANAGEMENT, SUPPLY CHAIN MANAGEMENT, AND BUSINESS PERFORMANCE: A STRUCTURAL ANALYSIS

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ABSTRACT

Just in time, quality management, and supply chain management are three philosophies firms have used to respond to competitive forces and enhance business performance. They are also complementary strategies that can be used as part of an integrated strategy to streamline material flows, reduce waste, and improve product quality, while satisfying market demands for shorter lead times, increased responsiveness, and lower cost. This study proposes and tests a structural equation model that relates just in time, quality management and supply chain management practices with a firm's supplier management practices and identifies their relationships with business performance. Results indicate that while just in time, supply chain management, and quality management strategies are mutually supportive, quality management alone has a direct impact on business performance.

INTRODUCTION

Firms have in recent years adopted just in time (JIT), quality management, and supply chain management practices in an attempt to respond to competitive pressures. The elimination of waste espoused by the just in time philosophy, the customer and continuous improvement focus of the quality management movement, and the integration of buyers' and suppliers' decision-making processes called for by supply chain management advocates, have each been promoted as ways to improve product quality, reduce lead times, increase responsiveness, and reduce product cost. While the foci and motivation of the three philosophies differ, the three are not mutually exclusive. For example, one of the goals of the just in time approach, which places substantial emphasis on supplier relationships, is to elicit quality improvements accruing from small lot production, while supply chain management seeks improvements in quality and materials management by bringing together buyers and suppliers early in the product development process.

While there is support for the notion that manufacturing excellence requires the use of multiple, complementary practices and strategies (e.g., Schonberger, 1986, 1990, Rehder, 1989), there is little empirical evidence to support it. Sakakibara et al. (1997) suggested that the impact of the JIT approach on performance is largely a function of the required strategic infrastructure, which includes a focus on quality management and the integration of the JIT philosophy into a broader strategic framework. Nakamura et al., (1998) suggested that improving manufacturing performance requires a strategy that embraces elements of both JIT and quality management philosophies. Flynn et al., (1995a) demonstrated that quality management and just in time practices were mutually supportive and that there were synergies attributable to their combined use. Tan et al., (1998) suggested that rationalizing the supplier base must occur in conjunction with efforts to improve quality to achieve benefits in business performance. This study extends prior research by developing a structural equation model that integrates JIT and quality management with efforts to manage the supply chain, and to identify the impact each has on each other and on a firm's business performance.

JIT, QUALITY MANAGEMENT, SUPPLY CHAIN MANAGEMENT, AND PERFORMANCE

The use of the JIT practices has been consistently shown to be associated with reductions in inventory (e.g., Callen, et al., 2000, Droge and Germain, 1998, Fullerton and McWaters, 2001, Germain and Droge, 1998, Huson and Nanda, 1995, Nakamura et al., 1998), improvements in quality (e.g., Fullerton and McWaters, 2001, Lawrence and Hottenstein, 1995, Nakamura et al., 1998), and improvements in throughout performance (e.g., Flynn et al., 1995a, Fullerton and McWaters, 2001, Lawrence and Hottenstein, 1995, Nakamura et al., 1998). Studies have also shown that the use of JIT is associated with improved business performance. In particular, improvements in both financial (Callen et al., 2000, Fullerton and McWatters, 2001, Germain and Dröge, 1998, Germain et al., 1996, Huson and Nanda, 1995, Mia, 2000), and market performance (Germain et al., 1996, Germain and Dröge, 1998) have been attributed to the use of JIT methods.

The quality management literature contains several studies identifying relationships between the underlying

dimensions of quality management and performance. Customer satisfaction (Anderson et al., 1995, Flynn et al., 1995), product quality (Ahire et al., 1996, Dow et al., 1999), as well as broader measures of manufacturing performance (Flynn et al., 1995b, Samson and Terziovski, 1999), have been shown to be positively associated with quality focused strategies. Studies have also demonstrated a positive relationship between the use of quality management methods and various measures of financial and market based performance (Handfield et al., 1999, Kannan et al., 1999, Powell, 1995).

While no evidence exists of the impact on performance of integrated supply chains, in which purchasing, manufacturing, and logistics are fully integrated, evidence does exist of the impact of logistics and purchasing specific supply chain management practices. From a logistics perspective, inter-firm coordination (Stank and Lackey, 1997, Stank et al., 1999, Fawcett and Clinton, 1996), functional integration (Stank and Lackey, 1997), a customer focused logistics strategy (Fawcett and Clinton, 1996, Stank and Lackey, 1997), and the management of logistics as an integrated activity (Fawcett and Clinton, 1996) have all been shown to be positively associated with operational performance. From a purchasing perspective, supplier development (Scannell et al., 2000), supplier partnerships (Scannell et al., 2000, Groves and Valsamakis, 1998), supplier involvement (Vonderembse and Tracey, 1999), and strategic sourcing (Narasimhan and Jayaram, 1998) all positively impact the buying firm's operational performance. In addition, supplier partnerships (Tan et al., 1998), supplier development (Curkovic et al., 2000) and supply chain flexibility (Vickery et al., 1999) have been shown to be positively impact the buying firm's business performance.

LINKING PARADIGMS

While JIT, quality management, and supply chain management can independently impact a firm's performance, they can also be elements of an integrated strategy aimed at improving performance by coordinating the strategies and objectives of supply chain members. To test this proposition, the following model is proposed:

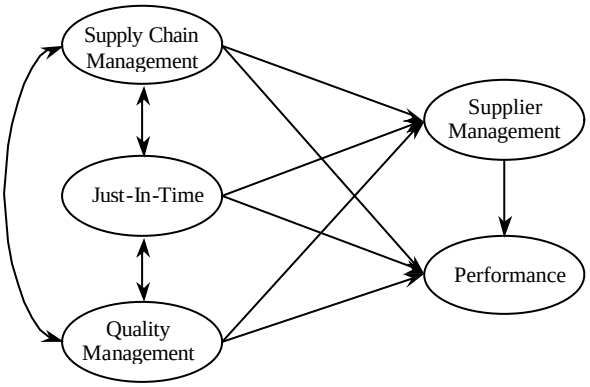

Figure 1. Proposed Structural Model

The underlying premise of the model is that efforts to improve quality, lead time performance, and thus business performance requires a coordinated effort to improve the efficiency of material flows, focus on quality, and drive out waste throughout the supply chain. While individual strategies can impact performance, synergies exist by implementing them in a mutually supportive manner. Suppliers are a crucial element of any manufacturing strategy. Their commitment to coordinating material flows, providing quality inputs, and supporting the strategic needs of the supply chain will impact the buyer's performance. This implies that buyers will pay attention to how they select and assess suppliers, and that evaluation criteria will be directly impacted by internal quality, supply chain management, and just in time strategies.

METHODOLOGY

A review of the literature and interviews with practitioners were carried out to identify appropriate indicators of supply chain management, quality management, just in time, and supplier management. Ten indicators of commitment to supply chain management, ten criteria used to select and evaluate suppliers, eight indicators of the importance of just in time principles, and thirteen quality management practices were identified (Appendix 1). Five point Likert scales were developed for each item that sought information on the importance of the item to the responding firm. Five commonly used measures of financial, market, and product performance were also identified. For each, a five point Likert scale was developed that sought information on the performance of the responding firm relative to that of its major competitors (Appendix 1).

A survey instrument was developed based on the constructs described above. It was developed so as to achieve a high degree of content validity and to reduce the risk of common method bias. The instrument was pre-tested by thirty senior purchasing and materials managers, and where necessary changes made. The revised instrument was mailed to senior purchasing and materials managers in North America and Europe that were identified from National Association of Purchasing Management (NAPM) and American Production and Inventory Control Society (APICS) membership lists. Efforts were made to target respondents familiar with their organizations' supply chain management, operations, and quality efforts, and who could make meaningful judgments regarding relative firm performance.

Five hundred and fifty six usable surveys were returned. Tests indicated that responses from North America and Europe were homogeneous and could thus be combined thus. Tests also indicated the absence of non-response bias. Responding firms varied in size from ten to two hundred thousand employees (median = 250), and had annual sales of between $ 20,000 and $ 30 billion (median = $ 30 million). Three hundred and seventy nine of the responses received (68%) indicated the use of supplier chain management practices. Subsequent analysis is based on these responses.

Reliability analysis was carried out to ensure that items used to operationalize the constructs of interest, measured the corresponding construct consistently, and were free of measurement error. While the analysis did suggest that some items be dropped, values of Cronbach's α (Cronbach, 1951) in excess of 0.70 (Nunnally, 1988) indicated that the resulting scales were reliable.

A two step approach to model development was used (James et al., 1982, Jöreskog and Sörbom, 1993). Measurement models that enable the construct validity of the latent variables to be assessed were first developed. Once construct validity had been established, the structural model was specified. All models were developed using LISREL8-SIMPLIS (Byrne, 1998, Jöreskog and Sörbom, 1993). Maximum likelihood estimation, which assumes multivariate normality of the observed variables, was used. To establish the scale for each latent variable, the first regression path in each measurement model was fixed at 1.

Each measurement model was examined to ensure that parameter estimates exhibited the correct sign and size and were consistent with underlying theory (Byrne, 1998). In some cases, error terms were large indicating that the corresponding measure was unimportant and should be dropped (Byrne, 1998). Analysis also indicated that in some cases, error covariance terms should be added to the corresponding measurement model. Models were modified accordingly (Appendix 2). In the absence of a single definitive test for goodness of fit, the comparative fit index (CFI), normed fit index (NFI) (Bentler, 1992), non-normed fit index (NNFI, Bentler 1990) and χ^2/d.f were used to assess goodness of fit of each model. Index values all suggested good model fit (NFI, NNFI, CFI > 0.90, χ^2/d.f < 3.0, Raykov and Marcoulides, 2000).

Analysis of the proposed structural model revealed that paths from just in time to supplier management and from just in time, supply chain management, and supplier management to performance were insignificant (Figure 2, $\alpha = 0.05$). These paths were deleted one at a time until no insignificant parameter values remained. With the exception of the value for NFI (0.83), all goodness of fit measures for the resulting model (Figure 3) suggested good model fit. In particular, the values of CFI and NNFI were both 0.92 and χ^2/d.f. = 1.6797.

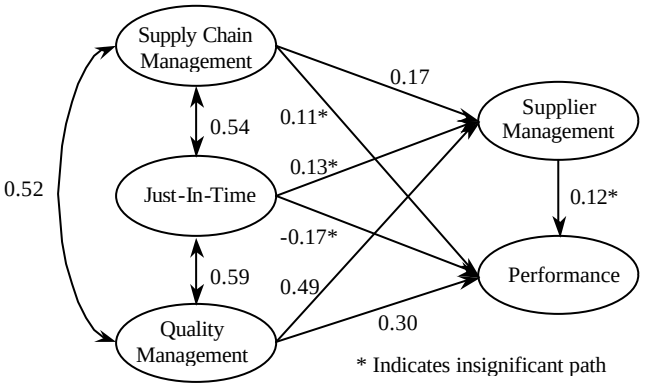

Figure 2. Initial Structural Model

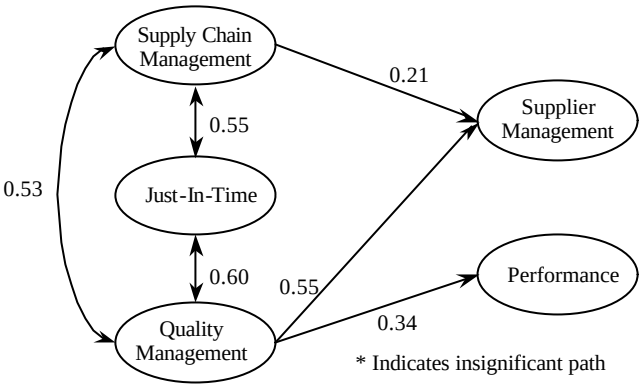

Figure 3. Final Structural Equation Model

IMPLICATIONS FOR OPERATIONS STRATEGY

Results support previous research claiming that quality management is a driver of a firm's business performance. However, they also suggest that just in time and supply chain management strategies do not affect business performance *directly* but do so via their impact on a firm's quality management strategy. The observation that a just in time strategy does not independently affect performance but does so by supporting a strategy founded on the principles of quality management is also consistent with past findings. Evidence of supply chain management strategy's indirect impact on performance is new. It suggests that involving supply chain partners in product development and production, ensuring that quality is emphasized in procurement activities, and coordinating objectives, schedules, and material flows, positively impacts product quality and in turn performance. This in turn implies a need to carefully select and assess suppliers, and to ensure that suppliers are identified whose strategic goals are aligned with those of the buyer.

One interpretation of the study's results is that while supply chain management, just in time, and quality management strategies are mutually supportive, just in time and supply chain management strategies are means of supporting and operationalizing a firm's commitment to quality, and in this regard are subservient to the quality management strategy. This in turn suggests that an appropriate information technology (IT) infrastructure be in place. IT is an enabler of not only the inter-firm communication needed between buyer and suppliers but the intra-firm communication needed to facilitate internal alignment of goals, decisions, and actions.

REFERENCES

[1] Ahire, S.L., Golhar, D.Y. & Waller, M.A. Development and validation of TQM implementation constructs. *Decision Sciences*, 1996, 27 (1), 23-56.

[2] Anderson, J.C., Rungtusanatham, M., Schroeder, R.G. & Devaraj S. "Path analytic model of a theory of quality management underlying the Deming management method: Preliminary empirical findings," *Decision Sciences*, 1995, 26 (5), 637-658.

[3] Bentler, P.M. "Comparative fit indexes in structural models," *Psychological Bulletin*, 1990, 107, 238-246.

[4] Bentler, P.M. "On the fit of models to covariances and methodology," *Psychological Bulletin*, 1992, 112 (3), 400-404.

[5] Byrne, B.M. *Structural equation modeling with Lisrel, Prelis, and Simplis: Basic concepts, applications, and programming*, Lawrence Erlbaum Associates, 1998.

[6] Callen, J.L., Fader, C. & Krinsky, I. "Just in time: A cross sectional plant analysis," *International Journal of Production Economics*, 2000, 63, 277-301.

[7] Cronbach, L.J. "Coefficient alpha and the internal structure of tests," *Psychometrika*, 1951, 16, 297-334.

[8] Curkovic, S., Melnyk, S., Calantone, R. & Handfield, R. "Validating the Malcolm Baldrige national quality award framework through structural equation modeling," *International Journal of Production Research*, 2000, 38 (4), 765-791.

[9] Dow, D., Samson, D. & Ford, S. "Exploding the myth: Do all quality management practices contribute to superior quality performance?" *Production and Operations Management*, 1999, 8 (1), 1-27.

[10] Dröge, C. & Germain, R. "The just in time inventory effect: Does it hold under different contextual, environmental, and organizational contexts?" *Journal of Business Logistics*, 1998, 19 (2), 53-71.

[11] Fawcett, S.E. & Clinton, S.R. "Enhancing logistics performance to improve the competitiveness of manufacturing organizations," *Production and Inventory Management Journal*, 37 (1), 40-46.

[12] Flynn, B.B., Sakakibara, S & Schroeder, R.G. "Relationship between JIT and TQM: Practices and performance," 1995a, *Academy of Management Journal*, 38 (3), 1325-1360.

[13] Flynn, B.B., Schroeder, R.G. & Sakakibara, S. "The impact of quality management practices on performance and competitive advantage," 1995b,*Decision Sciences*, 26 (5), 659-692.

[14] Fullerton, R.R. & McWatters, C.S. "The production performance benefits from JIT implementation," 2001, *Journal of Operations Management*, 19, 81-96.

[15] Germain, R. & Dröge, C. "The context, organizational design, and performance of JIT versus non JIT buying firms," 1998, 34 (2), 12-18.

[16] Germain, R., Dröge, C. & Spears, N. "The implications of just in time for logistics organization management and performance," 1996, *Journal of Business Logistics*, 17 (2), 19-34.

[17] Groves, G. & Valsamakis, V. "Supplier-customer relationships and company performance," 1998, *International Journal of Logistics Management*, 9 (2), 51-64.

[18] Handfield, R.B., Jayaram, J. & Ghosh, S. "An empirical examination of quality tool deployment patterns and their impact on performance," *International Journal of Production Research*, 37 (6), 1403-1426.

[19] Huson, M. & Nanda, D., "The impact of just in time manufacturing on firm performance in the U.S.," 1995, *Journal of Operations Management*, 12, 297-310.

[20] James, L.R., Mulaik, S.A. & Brett, J.M. *Causal analysis: Assumptions, models, and data*, Sage Publications, 1982.

[21] Jöreskog, K.G. & Sörbom, D. *LISREL8: Structural equation modeling with the SIMPLIS command language*, Lawrence Erlbaum Associates, 1993.

[22] Kannan, V.R., Tan, K.C., Handfield, R.B. & Ghosh, S. "Tools and techniques of quality management: An empirical investigation of their impact on performance," *Quality Management Journal*, 1999, 6 (3), 34-49.

[23] Lawrence, J.J. & Hottenstein, M.P. "The relationship between JIT manufacturing and performance in Mexican plants affiliated with U.S. companies," *Journal of Operations Management*, 1995, 13, 3-18.

[24] Mia, L. "Just in time manufacturing, management accounting systems and profitability," *Accounting and Business Research*, 2000, 30 (2), 137-151.

[25] Nakamura, M., Sakakibara, S. & Schroeder, R. "Adoption of just in time Manufacturing at U.S. and Japanese owned plants: Some empirical evidence," *IEEE Transactions on Engineering Management*, 1997, 45 (3), 230-240.

[26] Narasimhan, R. & Jayaram, J. "Causal linkages in supply chain management: An exploratory study of North American manufacturing firms," *Decision Sciences*, 1998, 29 (3), 579-605.

[27] Nunnally, J. *Psychometric Theory*, McGraw-Hill, 1998.

[28] Powell, T. "Total quality management as competitive advantage: A review and empirical study," *Strategic Management Journal*, 1995, 16, 15-37.

[29] Raykov, T. & Marcoulides, G.A. *A first course in structural equation modeling*, Lawrence Erlbaum Associates, 2000.

[30] Rehder, R.R. "Japanese transplants: In search of a balanced and broader perspective," *Columbia Journal of World Business*, 1989, 24, 17-28.

[31] Samson, D. & Terziovski, M. "The relationship between total quality management practices and operational performance," *Journal of Operations Management*, 1999, 17, 393-409.

[32] Sakakibara, S., Flynn, B.B., Schroeder, R.G., & Morris, W.T. "The impact of just in time manufacturing and its infrastructure on manufacturing performance," *Management Science*, 1997, 43 (9), 1246-1257.

[33] Scannell, T.V., Vickery, S.K. & Dröge, C.L. "Upstream supply chain management and competitive performance the automotive supply industry," *Journal of Business Logistics*, 2000, 21 (1), 23-48.

[34] Schonberger, R.J. *Japanese manufacturing techniques: Nine hidden lessons in simplicity*, The Free Press, 1982.

[35] Schonberger, R.J. *World class manufacturing: The lessons of simplicity applied*, The Free Press, 1986.

[36] Stank, T.P. & Lackey, C.W. Jr. "Enhancing performance through logistical capabilities in Mexican maquiladora firms," *Journal of Business Logistics*, 1997, 18 (1), 91-123.

[37] Stank, T.P., Crum, M. & Arango, M. "Benefits of interfirm coordination in food industry supply chains," *Journal of Business Logistics*, 1999, 20 (2), 21-41.

[38] Tan, K.C., Handfield, R.B. & Krause, D.R. "Enhancing firm's performance through quality and supply base management: An Empirical Study," *International Journal of Production Research*, 1998, 36 (10), 2813-2837.

[39] Vickery, S., Calantone, R. & Dröge, C. "Supply chain flexibility: An empirical study," *Journal of Supply Chain Management*, 1999, 35 (3), 16-24.

[40] Vonderembse, M.A. & Tracey, M. "The impact of supplier selection criteria and supplier involvement on manufacturing performance," *Journal of Supply Chain Management*, 1999, 35(3), 33-39.

APPENDIX I: SURVEY ITEMS

(1 = very low, 5 = very high)

1. How important are the following issues in your firm's supply chain management efforts?

   a. Improving integration of activities across supply chain
   b. Searching for new ways to integrate supply chain management activities
   c. Establishing more frequent contact with members of supply chain
   d. Communicating future strategic needs to suppliers
   e. Creating a greater level of trust among supply chain members
   f. Creating supply chain management teams that include members from different companies
   g. Reducing response time across the supply chain
   h. Involving all members of supply chain in your product/service/marketing plans
   i. Extending supply chain to include members beyond immediate suppliers and customers
   j. Creating a compatible information system with suppliers and customers

2. How important are the following issues when selecting and evaluating preferred suppliers?

   a. Service level
   b. Price/cost of product
   c. Certification
   d. Flexibility to respond to unexpected demand changes
   e. Quick response in event of emergency, problem, or special request
   f. Testing capability
   g. Technical expertise
   h. Commitment to quality
   i. Ability to meet delivery due dates
   j. Commitment to continuous improvement in product and process

3. How important are the following JIT principles in your operations?

   a. Reducing lot size
   b. Reducing setup time
   c. Reducing supplier base
   d. Preventive Maintenance
   e. Buying from JIT suppliers
   f Increasing delivery frequencies
   g. Reducing inventory to free up capital investment
   h. Reducing inventory to expose manufacturing and scheduling problems

4. How important are each of the following quality practices in your firm?

   a Inspection
   b. Using benchmark data
   c. Simplifying the product
   d. Statistical process control
   e. Using standard component parts
   f. Designing quality into the product
   g. Modular design of component parts
   h. Process improvement (modification of process)
   i. Employee training in quality management and control
   j. Empowerment of shop operators to correct quality problems
   k. Top management communication of quality goals to the organization
   l. Emphasis on quality instead of price in supplier selection
   m. Considering manufacturability and assembly in product design stage

5. What is the level of your firm's performance compared to your major industrial competitors in terms of

   a. Market share
   b. Return on assets
   c. Overall product quality
   d. Overall competitive position
   e. Overall customer service levels

APPENDIX 2: MEASUREMENT MODELS